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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN 455.

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# RED CLOVER.

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*With Notes on the Insect Enemies of Red Clover, by F. M. Webster,  
in charge of Cereal and Forage Insect Investigations,  
Bureau of Entomology.*



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## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF PLANT INDUSTRY,  
OFFICE OF THE CHIEF,  
*Washington, D. C., April 10, 1911.*

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript on Red Clover, prepared by Mr. J. M. Westgate, Agronomist in Charge of Clover Investigations, and Mr. F. H. Hillman, Assistant Botanist, Bureau of Plant Industry, with notes on insect enemies of red clover by Mr. F. M. Webster, in charge of Cereal and Forage Insect Investigations, Bureau of Entomology.

The increasing difficulty of obtaining successful stands of clover, where in former years it grew readily, constitutes one of the most serious agricultural problems of the present generation. The different viewpoints of the authors have been combined and it is thought that the data and conclusions presented will enable farmers in the clover-producing States to continue the growth of this crop with more certainty of success than is at present the case in many sections.

Respectfully,

WM. A. TAYLOR,  
*Acting Chief of Bureau.*

HON. JAMES WILSON,  
*Secretary of Agriculture.*

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# RED CLOVER.

## INTRODUCTION.

Red clover may justly be styled the corner stone of agriculturo in the North Central and Eastern States. Either alone or in mixtures with grasses for hay or pasture it generally constitutes from one-eighth to one-third of the total area of cultivated land on most successful farms throughout this area, and is an important crop far beyond these boundaries. For centuries it has constituted one of the important factors in maintaining a permanent system of agriculture in the Old World. In this country for a century and a half it has assumed a more and more important rôle in conserving the natural resources of the soil, thereby tending to maintain the profitable yields of the staple agricultural products.

Red clover is utilized both as a hay and as a pasture crop and often as a soiling crop. It is sometimes used as a green-manure crop to be plowed under if the ground is poor in humus. Even where it is cut for hay and only the roots and stubble turned under it has a marked influence in increasing the yields of succeeding crops. It makes an ideal hay for cattle and in the clover sections should constitute from one-half to two-thirds of the roughage ration of milk cows. Sheep and young stock of all kinds make excellent gains on either the pasture or the hay. In addition to its usefulness as a food for animals it has a most important effect upon the land in maintaining the supply of nitrogen in the soil. By means of the nitrogen-fixing organisms on its roots the red clover plant is able to gather large quantities of nitrogen from the air and leave it in the soil in a form which can readily be utilized by growing crops. It not infrequently happens that the yield of a grain crop can be doubled by the growing and plowing under of a crop of clover.

The most serious problem at present confronting the American farmer in many of the clover sections is the increasing difficulty of successfully maintaining stands of clover upon the farm.

With continuous cropping and the consequent depletion of the soil of humus and plant food the difficulty of growing red clover is greatly increased. This condition must be met and solved, since the loss of clover or its equivalent from the rotation leads rapidly to a run-down farm and unprofitable crop yields.

It should be emphasized, however, that the mere introduction of red clover into the farm rotation is not in itself a sufficient procedure to maintain indefinitely the productivity of the farm. The clover plant adds only the nitrates to the soil and removes large quantities of potash, phosphorus, and lime from the soil, especially when cut for hay and the manure resulting therefrom is not returned to the land. The increased supply of nitrogen may in fact stimulate the soil to increased yields temporarily, only to leave it after a few years in a condition worse than if no clover had been grown. The details of the proper handling of fields in this connection will be given

in the succeeding pages. The first part of the discussion will treat of red clover without reference to the grass mixtures which are often seeded with it.

### HISTORY AND PRESENT DISTRIBUTION OF RED CLOVER.

Red clover is native to the greater part of Europe and portions of Asia. Most writers hold that it was not cultivated by the ancients, although Virgil, writing in Italy about 2,000 years ago, advocated the use of cloverlike plants for improving soil and as a valuable feed for milk cows. It is probable, however, that the plants to which he referred did not include the red clover. It is known to have been grown in Spain and Italy as early as the fifteenth and sixteenth centuries, but did not reach England apparently until 1633, being introduced from Flanders (Netherlands). The exact date of its

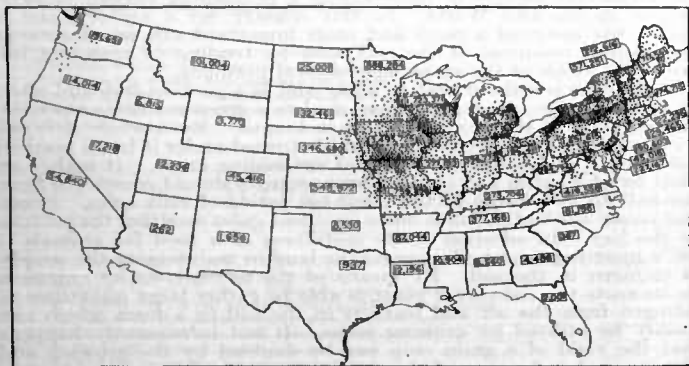


FIG. 1.—Map of the United States, showing the distribution in 1910 of clover and mixed clover and timothy.

introduction into this country is not known, but in a work on agricultural plants, written in 1747 by Jared Eliot, observations concerning its adaptability to conditions in the New England States are noted. Since its introduction into this country, it has spread extensively and is now grown to a considerable extent in practically all the sections of the United States where there is sufficient rainfall. In the irrigated sections of the arid portions of the West, alfalfa is usually produced instead of red clover, on account of its long life and the greater number of cuttings possible per season; but even in the irrigated sections in mountain valleys red clover is an important forage crop.

The accompanying map (fig. 1) shows the distribution of all clovers and of mixed clover and timothy in the United States according to the census of 1910. Each dot indicates 10,000 acres in the region where the dot is located. Counties having less than 5,000 acres are not dotted.

## DESCRIPTION OF THE RED CLOVER PLANT.

The accompanying illustrations (figs. 2 and 3) indicate the general appearance of the red clover plant. The plant is entirely herbaceous and is composed of numerous leafy stems arising from a crown. It usually lives only two years and for this reason is especially adapted to short rotations. The flowers are borne in compact clusters or heads at the tips of the branches. There may be a hundred or more flowers to a single head. The flowers are rose-pink, somewhat similar in shape to pea flowers but much more elongated and smaller, being one-half inch in length and one-sixteenth inch in width. The pods bear little resemblance to the pods of most other legume-bearing plants; they are small, short, and break open transversely instead of longitudinally as do pea and bean pods. (See fig. 4.) The kidney-shaped seeds are one-twelfth of an inch long and vary in color from yellow to purple. The stems comprise about three-fifths of the total weight of the plant above ground and are usually somewhat hairy. Each leaf is divided into three oblong leaflets, usually with a pale spot in the center of each. The roots are much branched but usually deep feeding and are ordinarily well supplied with the nitrogen-gathering tubercles (fig. 3).



FIG. 2.—Stems of red clover in different stages of bloom.

## ADAPTABILITY OF RED CLOVER TO VARIOUS SOILS AND CLIMATES.

Red clover is the staple leguminous forage crop in the North Central and Northeastern States. Although the distribution map (fig. 1) shows clover to be grown principally in the States bordering the Great Lakes, a great deal of clover is also raised in North Dakota, South Dakota, Montana, Oregon, Washington, and the Southwestern States. It does not give its best returns in the extreme South nor is it always quite able to withstand the more severe winters in North Dakota and Minnesota.

In irrigated sections clover can be grown, but usually it can not compete with alfalfa, which makes more cuttings in a season and lasts much longer from one seedling than the red clover plant. In some irrigated sections red clover is preferred, as in high mountain valleys where the growing season is too short for three crops of alfalfa and especially where a leguminous hay crop is desirable in connection with the customary grain crop. It makes its best growth on rich, fertile, well-drained soil containing an abundant quantity of

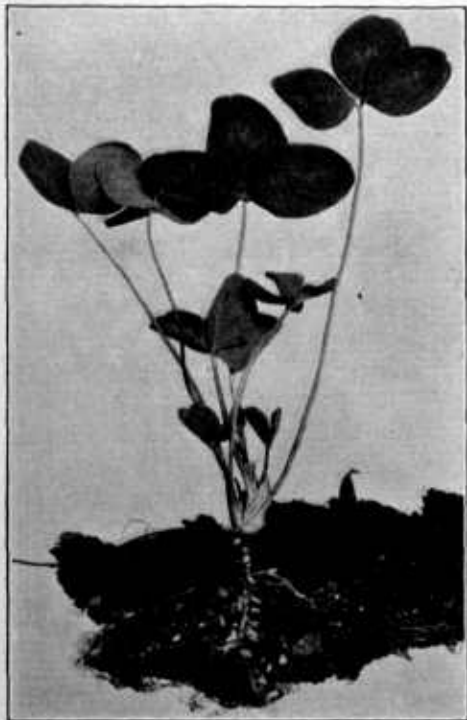


FIG. 3.—Young red clover plant, showing tubercles on roots.

lime and reasonably free from weeds; but it is not so exacting as alfalfa in these respects. To low, poorly drained soils it is not so well adapted as alsike clover. Alsike will also succeed on the so-called clover-sick lands upon which for one reason or another red clover can no longer be successfully grown.

# REQUIREMENTS FOR OBTAINING A STAND OF RED CLOVER.

## CHOICE OF SEED.

It is important that considerable care be taken in choosing the seed to be sown. If poor seed be used the expected crop may be a partial or total failure. In addition the loss of the labor involved in putting in the crop may be a considerable item of expense. It is essential to know the characteristics of both good and poor seed in order that an intelligent selection may be made.

**Characteristics of good seed.**—Good red clover seed is plump or well filled, bright with a slight luster, the color of individual seeds ranging from violet to light yellow. The individual seeds should be at least of medium size and fairly uniform. The seed should be free from adulterants of any kind and also free from seeds of noxious weeds. Very new seed is often undesirable to sow because of the hard seed it contains.

**Hard seed.**—The so-called hard seed has a coat in such a condition that it absorbs moisture very slowly and may not germinate for a period of several weeks or even months. In very new seed the proportion of hard seed may amount to as much as 50 or 60 per cent. A year or two later a much greater proportion of the same seed will germinate promptly. A germination test readily shows the proportion of hard seed present in any given sample.

**Advantages of home-grown seed.**—Several advantages attend the use of home-grown seed. In the first place it is quite certain to produce a crop especially adapted to the local climatic conditions, more so than seed brought in from a distance and usually from an unknown source. Home-grown seed is not likely to contain impurities foreign to the neighborhood and it is usually possible to obtain seed from fields known to be free from dodder, buckhorn, dock, etc. The age of home-grown seed may usually be definitely determined. This is usually impossible with seed purchased in the open market. Open-market seed may be excellent or it may be very undesirable. If seed is to be purchased from other localities care should be taken that it comes from a region possessing at least as rigorous a climate, especially if there is any necessity of seeding a hardy strain of clover.

**Characteristics of poor seed.**—Red clover seed may be poor and undesirable from several points of view. Such seed is constantly being sold to farmers and should be recognized and rejected. It may be poorly developed, many seeds being shriveled and dull brown in color. Such seeds will not produce plants. Often red clover is adulterated by the use of yellow trefoil, dead clover seed, cheap imported seed, or weedy screenings. Each of these constituents reduces the stand of healthy plants and makes the purchaser pay

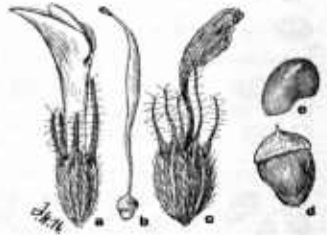


FIG. 4.—Stages in the development of red clover seed: *a* and *c*, flower in prill and ripe; *b* and *d*, immature and mature seed vessel; *e*, mature seed.

for what he does not get, transportation included. He is also likely to get an undesired crop of weeds, some of which may become a decided menace to his locality.

**Cleaning red clover seed.**—Some of the weed seeds appearing in red clover seed can be removed by the farmer by the use of a wire-cloth sieve containing 20 meshes to the linear inch. Most of the clover seeds of medium size are held back by such a sieve and practically all the smaller weed seeds pass through. The true clover dodder which is a very noxious pest in clover fields is quite effectively

removed in this way. Most of the seeds of the field dodder are also removed.<sup>1</sup> Seed of buckhorn, wild carrot, wild chicory, thistles, and others of similar size (fig. 5) are mostly held back by the sieve. The small-grained clover seed imported from Europe largely passes through such a sieve. A method of separating buckhorn seed from clover has been devised and published by the United States Department of Agriculture.<sup>2</sup> In brief this method consists of mixing with the seed containing the buckhorn thoroughly wetted sawdust. The buckhorn seed becomes sticky on being wet and readily attaches itself to the sawdust. The entire mass is then immediately screened when the larger particles of sawdust with the buckhorn attached are readily separated from the clover seed. This work should be done immediately before sowing the clover seed which with the small particles of sawdust that pass the screen need to be dried only sufficiently to enable the seedling to take place readily.



FIG. 5.—Seeds of red clover and common impurities.

This is an effective means of removing practically all viable buckhorn seeds and is easily accomplished by the farmer who handles a comparatively small quantity of seed which is not necessarily bulked immediately after the somewhat damp seed has been screened out.

**The purchase of red clover seed.**—The quality of the seed as previously discussed should receive more attention than has usually been given it. If home-grown seed produced under known conditions is not available, samples should be procured from reliable dealers.

<sup>1</sup> See Farmers' Bulletin 306, entitled "Dodder in Relation to Farm Seeds," by F. H. Hillman.

<sup>2</sup> Shaw, H. B. An Improved Method of Separating Buckhorn from Red Clover and Alfalfa Seeds. Circular 2, Bureau of Plant Industry.

These should be examined for adulterants, weed seeds, and shriveled seeds. They should also be tested for germination before purchasing. Cheap, poor seed is often mixed with good seed and sold at the price of good seed.

**Making the seed test.**<sup>1</sup>—In the absence of more accurate methods an estimate should be made of the proportion of true red clover seed and of weed seeds and other impurities. From the red clover seed separated from all impurities a counted number, as 100, should be taken just as they come. These seeds should be placed between layers of moistened cloth or paper or merely covered in a bed of sand



FIG. 6.—Homemade seed tester or germinator.

or light soil. The germinating receptacle (fig. 6) should be held at a temperature of a living room, varying between 65° and 85° F. Between the third and sixth days the sprouting ability of the seeds should be shown. Seeds which at the close of a week are still hard, not yielding to the pressure of a knife blade, are "hard" seeds and are to be considered little better than dead seeds for sowing. It should be borne in mind that the sowing value of the seed is represented by the amount of true clover which will germinate with reasonable promptness. Thus, if four-fifths of a sample is pure clover and but three-fourths of this clover will sprout, then only three-fifths or 60 per cent of the original seed as offered will grow. The examination of the seed is facilitated by the use of a magnifier; the kind shown in figure 7 is easily obtainable for about 50 cents. Some of the more important weed seeds are shown in figure 5.



FIG. 7.—Simple magnifier for examining seeds.

#### SOILS ADAPTED TO RED CLOVER.

As a general rule throughout the clover belt any soil that will grow corn successfully will produce satisfactory crops of red clover. A deep soil is desirable for red clover in order that it may utilize fully its extensive root system, which may extend down as far as 5 or 6 feet. Red clover is a legume that will grow in soil relatively low in nitrogen so long as there is a sufficient supply of this element to start the plants, until they have opportunity to develop tubercles on the roots. Absence of sufficient humus, however, makes it very difficult if not impossible to secure a profitable stand of clover. Red clover will not succeed if the ground is poorly drained or if the land is in any way boggy. On such soils it is better to seed alsike instead of red clover. One effect of poor surface drainage, especially on uplands, is to induce

<sup>1</sup> For detailed directions for making seed tests, see Farmers' Bulletin 428, entitled "Testing Farm Seeds in the Home and in the Rural School," by F. H. Hillman.

heaving during the winter and early spring. The surface drainage of the field may often be facilitated by backfurfrowing, leaving the dead furrows at intervals of 1 rod or less. These furrows furnish means for the storm waters to run off quickly in the event of heavy rains. The limestone areas of the country are usually very well adapted to the production of red clover. Where the soil is decidedly deficient in lime, as in many eastern States and in some portions of eastern Ohio, southern Indiana, and Illinois, this mineral must usually be supplied artificially.

#### PREPARATION OF THE SEED BED.

Clover is usually seeded in the spring on winter grain. In such cases no special preparation of the seed bed is necessary, as the frost has usually cracked the ground sufficiently to render natural covering a reasonable certainty. If seeded with a spring-sown nurse crop the preparation accorded the land for the grain crop is usually sufficiently thorough for successful results with red clover; but it is necessary to have the seed bed fine and reasonably firm if prompt germination and proper establishment of the young plants is to be accomplished.

When clover is seeded alone—a very desirable practice on poor, run-down farms—a firm, fine, well-settled seed bed is highly desirable. For this reason the clover should not be seeded on freshly plowed land which has been given no opportunity to settle. Several workings with soil packers or harrows are usually necessary unless a heavy rain intervenes to settle the ground to the proper condition. If the ground has been previously planted to an intertilled crop, such as corn, plowing is not always necessary, as a good disking will generally put the ground in proper condition for red clover. It should be remembered that red clover, especially in its early stages of development, is not drought resistant; in seasons of drought, or on land which drought affects badly, special care should be taken looking to the conservation of the moisture in the soil.

#### FERTILIZERS FOR RED CLOVER.

Under ordinary conditions the red clover crop is able to succeed by utilizing whatever fertilizer has been used in connection with the crops immediately preceding or with which the clover is sown; but on soils which are somewhat low in fertility profitable returns are made more certain by top-dressing with manure previous to the time of seeding. (Fig. 8.) The soil may lack a sufficient quantity of one or more of the principal fertilizer elements essential to the production of red clover. This deficiency may be supplied in the form of commercial fertilizer if manure is not available in sufficient quantities. Clover soils in the clover belt generally appear to be somewhat deficient in phosphorus but usually have enough potash and nitrogen.

When barnyard manure is used as a top-dressing, from 6 to 10 tons per acre should be scattered, preferably with a manure spreader, as this insures a fine and even distribution. The manure may often be applied advantageously to the preceding crop, especially if it be a crop like corn, the cultivation of which kills the weeds. A sufficient residue will usually be left to produce a satisfactory growth of the

young clover plants. Wood ashes when available may also be applied.

The use of such soil amendments as lime and gypsum very often gives large returns for the comparatively small outlay for their application. Such materials usually act not so much in supplying food to the plant as they do in neutralizing any acidity which may be in the soil or in liberating other plant foods, thus enabling the clover plants to make a better growth. During recent years the use of lime and potash has largely supplanted the use of gypsum for clover except in Oregon and Washington. (Fig. 9.) When lime is used 600 to 2,000 pounds per acre of quicklime applied as a top-dressing and thoroughly worked into the soil may be used, or 1 to 2 tons of ground, unburned limestone. If available the latter form is recommended unless carriage charges make it considerably more expensive.



FIG. 8.—Red clover field, showing the effect of top-dressing with manure. The area in the immediate foreground received no manure; the area immediately behind received a light application, resulting in a very vigorous stand of clover.

When gypsum is applied it is scattered at the rate of 40 to 200 pounds per acre. On poor, sandy soils an application of 200 pounds of bone meal or 250 pounds of acid phosphate (containing 12 to 14 per cent of available phosphoric acid) and 50 to 100 pounds of muriate of potash usually makes a very satisfactory top-dressing for all kinds of clover. On most clay-loam soils the bone meal or acid phosphate alone is ordinarily sufficient without the potash.

### SEEDING RED CLOVER.

Red clover often fails to catch because it is not planted sufficiently deep to insure proper moisture conditions for the young seedlings. In light or sandy soils the seed should be covered  $1\frac{1}{2}$  to 2 inches deep, while in clay soils the covering should be about 1 inch. For prompt germination it is advisable on reasonably loose lands, especially sandy lands, to roll the ground after seeding. If a smooth roller is used, it should be followed by a light harrow to roughen the surface

and thus prevent rapid evaporation of the soil moisture. Shallow seeding is especially disastrous in case of insufficient rainfall. Red clover may be seeded about six weeks before frost in the autumn or in the early spring while the ground is still freezing and thawing daily. It may also be seeded in the late spring after the ground has become warm. The late summer or early fall seeding is recommended in seasons where there is ample moisture or where spring seedings for any particular reason do not succeed.

It is a practice with many to seed clover as early as February, while others may wait until April with apparently equal success. Still others sow half the seed early and half late since a very light seeding will suffice if the conditions are exactly right. It may be



FIG. 9.—View showing the marked effect of land plaster on the growth of red clover. The dark streaks at the right and at the left show the heavy growth where plaster was applied; the light streak in the center shows the scanty growth where no plaster was applied.

seeded on a late snow with good chances of success. One advantage of early spring seeding is that it may be done when other farm work is not pressing and very little labor is necessary in connection with the seeding operation. In the event of failure, the farmer loses but very little besides the seed used. If the soil is plentifully supplied with humus and if moisture and other conditions are favorable, a fairly good catch of clover may be expected, but at best there is considerable uncertainty, and in the older and more run-down soils this uncertainty is becoming greater and greater each year. A failure of the seed to catch is a serious matter, as the elimination of clover from the rotation is rapidly followed by decreased yields of the standard grain crops. It must be admitted that the mere seeding of

the red clover on wheat without any other attention is not giving the red clover the best possible chance of success.

Other methods of obtaining a catch of red clover, much more certain than the usual one just outlined, call for an increased amount of labor in preparing the seed bed, and under some conditions for the entire use of the land for the better part of the season. The early spring seedings are the rule where red clover grows readily. Under such conditions it is seeded in winter grain upon the land when in "honeycombed" or tessellated condition; that is, filled with small frost cracks, in which the seeds find lodgment (fig. 10). In many localities where difficulty is experienced in obtaining satisfactory stands of clover by seeding in the usual way on wheat in the early spring, it has been found advisable to harrow the wheat when the clover is seeded. The more certain method appears to be to harrow

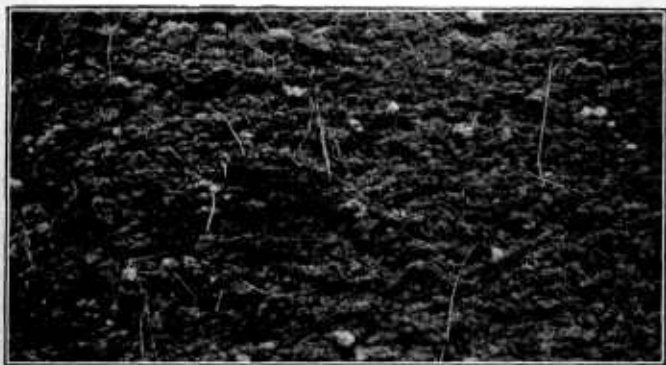


FIG. 10.—Close view of soil honeycombed by frost and in proper condition for seeding clover. The numerous irregularities become leveled when the ground thaws, resulting in a natural covering of the clover seed by the soil.

the wheat immediately in advance of the seeding and then reharrow to cover the clover seed. This insures a deep covering of the clover and a better establishment of the plants. This harrowing will prove especially advantageous in the event of any lack of rainfall which may occur during the season. The harrowing does not appear to injure the wheat. If timothy has been seeded in the wheat the fall before, some of the young seedlings will be destroyed, but enough will survive the two harrowings to give a satisfactory stand. Being of greater importance than the timothy, the clover should have first consideration. When the clover is to be put in with a harrow, it is important to wait until the field is in a good condition to harrow. The seeding should be done at the earliest possible moment that the soil conditions are right, but this may call for a delay in seeding until as late as the first of May. It is not well to put off the seeding until the wheat gets so high as to interfere with the harrowing operations.

The harrow should be set to cover the seed to a depth of about 1 inch. The greatest objection to this method is that the work must be done when the preparation of the ground for other crops is under way. Owing to the fact that the clover is of such great value as a soil improver, together with its importance as hay, this means of obtaining a good stand of clover can not be urged too strongly in sections where the usual method of seeding fails. If an early seeding on snow or frozen ground fails, a later seeding can be made and harrowed in. A successful stand of clover is important, even at the expense of one or two reseeds. If not seeded on winter grains by one or the other of the methods already noted, it is usually sown with a spring-seeded grain crop, both the clover seed and grain being put in at the same time. However, the grain is usually planted at a somewhat greater depth than the clover.

Red clover may be seeded either broadcast or with one of the various makes of seeders or with a regular grain drill with a seeder attachment. Some care and experience are necessary in seeding broadcast by hand in order to get an even stand with the small quantity of seed usually used. An advantage which the clover seeders offer is that no special experience is necessary in evenly seeding the desired quantity per acre. One successful type of seeder consists of a seeding attachment in front of a 1-horse weeder, which covers the seed to the proper depth in reasonably firm soils. When seeded with grain, better results are usually obtained by cross seeding the clover, as in this way the ground not utilized by the grain is available to the clover plants. Otherwise the two have to struggle for supremacy in the same row, often to the injury of each. In northern Indiana and a few other places it is coming to be a more or less common practice to use a disk drill in sowing red clover in wheat, but some use a shoe drill. In using a drill for this purpose the seeding attachment should be placed in front of or just back of the drill. With shoe drills the clover seed is allowed to drop through the grain tubes. This is a very effective method of getting a good stand of clover. The wheat rows should run north and south in order to give the clover the greatest quantity of sunlight. In seeding clover, 8 to 10 pounds are usually sufficient. This weight of seed is often mixed with 10 to 12 pounds of timothy.

#### USE OF NURSE CROPS WITH RED CLOVER.

Where no difficulty is experienced in growing red clover, it is the customary practice to seed with some nurse crop. In sections growing winter wheat it is usually seeded on the wheat in early spring, when the alternate freezing and thawing of the honeycombed ground covers the seeds sufficiently to render a good stand reasonably certain. In sections where the seeding of spring-sown grain is the rule it is the general practice to seed the clover either with or immediately after the grain. In light sandy soils the two may be drilled into the grain furrows, as under such conditions the deep covering of red clover is an advantage. On other soils it is necessary to cover the clover to a less depth than the grain, and this may be brought about by seeding the clover in front of the drill shoes or by seeding it after the drill and harrowing it in. When seeded in the spring on fall-sown grain, wheat is the usual nurse crop, but rye is

more favorable to the growth of clover, because it produces less shade than wheat. If the rye is used in spring for pasturing, the trampling incident to the pasturing will assist in covering the clover seed.

Of the various nurse crops, oats are perhaps most unfavorable to the growth of the clover on account of the dense shade produced; but the value of the oat crop itself makes it often to be preferred to

such crops as barley, which is less injurious to the clover because it makes less shade. The advantages of a nurse crop are (1) that a grain crop is produced, avoiding the loss of the use of the land for one season, and (2) that the stubble of the grain serves as a winter protection to assist in catching and holding the snow which otherwise might drift from the field and render the clover plants more liable to be winterkilled. In sections where there is frequently a lack of timely rains a nurse crop greatly decreases the chances for a successful stand of clover.

Another method distinct from that of seeding in the spring with spring-sown grain or on a stand of fall-seeded grain is that of seeding in corn at the last cultivation, and this method is coming more and more into use. (Fig. 11.)

This method gives fair results unless there is lack of rainfall during the late summer and early fall; but it does not appear to give satisfactory results on clay uplands. North of central Ohio and Indiana this method may result in the winterkilling of such of the young plants as are unable to make more than a 6-inch growth before cold weather. If moisture conditions are favorable there is usually sufficient sunlight for the development of the young



FIG. 11.—A cornfield in which clover was seeded at the last working of the corn.

clover plants, and a good crop of hay is possible the next season without the loss of the use of the land for a season. This method is commonly practiced throughout the New England States and has been recommended in sections where clover does not do well when seeded in the spring with a nurse crop.

Successful stands have also been produced by seeding with rape in late summer. When the rape is fairly well grown it is grazed down without much injury to the clover. Seeding with turnips after early potatoes is sometimes practiced in the eastern States. Some farmers practice the method of plowing down some red clover that has matured seed when turning under the sod. When the land is replowed this seed usually germinates sufficiently well to produce a fairly satisfactory stand. For this purpose late fall or early spring plowing is best.

### SEEDING WITHOUT A NURSE CROP.

Where none of the methods already discussed prove successful it is necessary to seed the clover alone and give the crop the entire use of the ground. By seeding clover in the spring without a nurse crop, a good crop of hay may be obtained the first season, the stand is more certain, and the plants are not injured by the lodging or shading of the grain. If weeds prove troublesome, they may be clipped back with the mower. Should there be any tendency to drought during the summer, the water supply available for the clover plants is much greater when seeded alone than when seeded with a nurse crop. The land should be thoroughly prepared and well settled and the seed sown and covered to depths ranging from one-half inch in heavy soils to 2 inches in very light sandy soils. In the northern States seeding alone any time from early spring until the middle of August may be successfully practiced. Except in the extreme north, seeding as late as August 15 allows the plants time to make a fair growth before winter, and good yields of hay can be expected the following season. By following such a crop as early potatoes or grain, this method entails no loss of the use of the land. The extra labor incident to the preparation of the land for the crop is the principal drawback to this method, which is usually much more certain in its results than seeding with a nurse crop.

### INOCULATION OF RED CLOVER.

In order to make its best growth, the red clover plant must be supplied with nitrogen-gathering bacteria on its roots. The tubercles containing these bacteria are shown in figure 3. Fortunately, this crop has been grown so long in this country that most soils appear to be fairly well supplied with these germs, and usually no artificial application of them is necessary. When the clover is being tried as a new crop in a section it often does not become well inoculated until it has been grown for two or three seasons on the same piece of land, after which natural inoculation takes place and good crops are grown without further difficulty. By scattering the clover straw and chaff (remaining after hulling the seed) on the land to be seeded to clover, it has been observed that beneficial results follow, more in fact than would naturally be expected merely from the manurial effect of the clover stems so applied. It is probable that a portion

of the observed increase in the vigor of the clover plants is due to the bacteria which may be applied with the leaves and chaff. When seeding clover upon land for the first time, it is well to provide for artificial inoculation, but after clover is established on a farm this procedure is usually unnecessary. This artificial inoculation may be accomplished either by scattering soil from some old, healthy, weed-free clover field or by the use of pure cultures.<sup>1</sup>

**The soil-transfer method of inoculation.**—Inoculation by the soil-transfer method is generally more certain in its results than the pure-culture method, but where the soil is brought in from some outside locality not known to be free from noxious weeds, insect enemies, and plant diseases, there is danger of introducing such pests.

The soil-transfer method consists in scattering over the new ground, at the rate of 200 to 300 pounds to the acre, soil from a healthy clover field where the plants show an abundance of the tubercles on their roots. It is suggested that the seed be mixed with a small portion of this soil and the remainder drilled or scattered broadcast and immediately harrowed in. This should be done preferably on a cloudy day or toward evening, as the sun's rays are very injurious to the germs; but if the person who scatters the soil walks directly in front of the harrow the sun has practically no opportunity to harm the germs. To facilitate even scattering, the soil may be mixed with two or three times its own weight with ordinary soil obtained close at hand to save carriage charges.

**The pure-culture method of inoculation.**—The results with pure cultures are less certain than where the soil-transfer method is employed, but the pure-culture method has the advantages of greater ease of transportation and freedom from danger of introducing harmful pests upon the farm. The method of inoculation by pure cultures may be carried out in either of two ways: (1) A bottle of pure culture of the proper kind of bacteria is opened and the culture mixed with a convenient quantity of water; this diluted culture is new thoroughly mixed with a considerable quantity of soil, preferably from the field where the legume is to be sown; the treated soil is then distributed in the same manner as when inoculation is made by the use of soil from an old field. (2) A pure culture of the proper kind of bacteria is prepared according to the directions accompanying the bottle, and is then applied to the seed in such a way that all of the seed may be moistened, though not soaked. The seed should be planted as soon as practicable after this treatment—that is, as soon as it is sufficiently dry for convenient handling. Drying may be facilitated by adding dry, sifted earth, preferably from the field in which the leguminous crop is to be grown. The nodule bacteria very often die within a week after the seed is inoculated and dried; it is therefore highly desirable that the inoculation be made the same day the seed is sown. Inoculated seed should never be dried in the sun, as direct sunlight is quickly fatal to the bacteria.

#### TREATMENT THE FIRST SEASON.

When seeded with a grain nurse crop no special treatment is given the clover the first season. It develops in the stubble after the grain has been cut and occasionally may afford some pasture the same

<sup>1</sup> See Circular 63, Bureau of Plant Industry

fall. If the late summer be especially favorable sufficient growth may be made for a cutting of hay, and in some cases a crop of seed has been secured. The stand, however, is apt to be injured by the cutting, and it is usually best to clip back the growth to check the development of the plants. When seeded in the fall in corn or with rape one or two crops may be expected the next season in addition to considerable pasture. A top-dressing of barnyard manure acts very favorably on red clover at any time. A light top-dressing of gypsum may also be of advantage if the clover appears to lack vigor. This can be applied on the young plants when about 6 inches high, and even in early spring the following year (fig. 9). It is not advisable to pasture spring seedlings the same season with sheep or hogs, as they are likely to injure the young plants. Pasturing with cattle is less injurious.

#### TREATMENT THE SECOND SEASON.

Common red clover usually lives but two years. The second season the first crop is usually cut for hay and the second crop for seed. The aftermath or rowen is then pastured or plowed under. In sections where the season is not long enough to permit the clover to set seed after a full hay crop has been harvested it is necessary if seed is desired either to pasture back the first crop of clover or to cut it early when just coming into bloom, rather than to wait until it is in full bloom, as is usually recommended. When mixed with timothy the stand is often allowed to remain three or four years with the clover gradually decreasing. If it is desired to retain a stand of clover for more than two years seed must be allowed to mature during the late summer the second season. This may reseed the area naturally, but it is well to give the ground a good harrowing to cover the seed and properly scatter it. A top-dressing with clover straw or with manure made from clover hay will also tend to thicken up the stand by reason of the seeds which are present therein. Although no definite experimental evidence is at hand it is probable that by leaving occasional uncut strips of red clover across the field when cutting the seed crop this will furnish sufficient seed to reseed the ground when harrowed across the narrow uncut strips.

#### NEED OF EXPERIMENTS WITH RED CLOVER.

Red clover is a well-known crop in most sections of the United States, but there is yet much that might be learned by the individual farmer in regard to the special requirements of the clover crop upon the particular fields and soils in question. By devoting a small portion of the field to experimental uses, the relative merits of a number of different practices can be readily determined. Should any of these methods prove superior to the ordinary treatment given the remainder of the field it can be used for increased areas during succeeding seasons.

Among the points that can be readily determined by experimenting on narrow strips across one end of the field are: (1) Time of seeding; (2) rate of seeding; (3) use of a nurse crop as compared with no nurse crop; (4) barley compared with oats as a nurse crop; and (5) the relative merits of different varieties of clover, different fertilizers,

and different amounts of lime. Later, strips may be cut at different times to determine the effect on seed production and yield of hay.

In all such experimental strips it is important to provide a check strip to be given only the usual treatment, to serve as a definite basis of comparison in determining the relative value of the different special treatments. The accompanying diagrams illustrate this method, which is readily adapted to the determination of the value of any system of practice as compared with the ordinary method.

*Suggested outlines for experiments to determine the need of clover for lime, manure, potash, and phosphoric acid.*

No lime or manure.
Lime only.
Manure only.
Lime and manure.

Potash and phosphoric acid.
Potash only.
Phosphoric acid only.
Neither potash nor phosphoric acid.

The outline shown in the second diagram will be found useful in sections where it is thought that some commercial fertilizer is essential. By applying lime to a narrow strip running across the strips shown in the diagram the exact value of lime in connection with the different fertilizers can be definitely determined.

These outlines are given primarily to illustrate the principle of definite experimentation and the method can be used to determine which is the best of any series of practices for a particular set of conditions.

## HANDLING THE RED CLOVER CROP.

### RED CLOVER HAY.

**Time of cutting red clover hay.**—In order to obtain the best hay, the clover crop should be cut, as a general rule, when just past full bloom. At this stage a maximum of protein and dry matter is present, the leaves are still intact, and the stems green. After this stage the leaves begin to fall and the protein content is in other ways reduced. It frequently happens, however, that due consideration for the success of the second crop, which is usually allowed to stand for seed, makes it necessary to cut the first crop somewhat earlier than at the best haying stage in order to avoid injury from certain insect enemies. The disadvantages of cutting hay before it is in full bloom are due to the fact that the young growth is then quite sappy and considerably more difficult to cure into a good quality of hay.

**Methods of harvesting red clover hay.**—The methods of harvesting red clover hay vary somewhat in different sections of the country. In general it is desirable to so handle the hay that it will reach the barn or stack with the least possible exposure to the weather and the minimum loss of leaves. Clover should not be allowed to become too dry in either the swath or the windrow, else the leaves will crumble,

resulting at best in a very dusty hay, to say nothing of the actual loss of much of the nutritive value. If the hay can be cocked before the leaves are entirely dry the movement of the water from the stems through the leaves will continue. When the leaves become well wilted in the swath it should be raked into windrows and then bunched into cocks when the hay is about half dry. Each cock should contain only enough hay so that two men can place the entire cock on the wagon at once, as in this way the loss of leaves due to handling is reduced to a minimum. Where a prime or choice quality of hay is desired and the rains are frequent hay caps for the cocks and canvas covers for any outside stacks are valuable devices. These hay caps can be made from a 40-inch square of canvas or ducking and may be held in place by small weights attached to each corner. Cement weights about the size of a baseball which may be attached to the hay cap by means of a hook and eye are satisfactory. Any excess of clover hay is usually baled for the market, but under ordinary circumstances the farm produces only enough hay to maintain the live stock which the place supports.

One successful method of curing hay in use by a Tennessee farmer is to cut when half the blossoms are dead. The mower is run the entire day; the next morning, after the dew is off, the hay is raked into windrows, put into medium-sized cocks, and allowed to remain for 24 to 36 hours. The hay is forked over once to prevent heating and is then put in the barn. In threatening weather the hay is put into the barn at the end of 24 hours, but it is preferable to leave it in the field for a somewhat longer time.

Another method which has been locally successful under favorable conditions is to mow as soon as the dew is off, endeavoring by 11 o'clock to have enough cut to last the haulers from 1 to 5 o'clock in the afternoon. The newly cut clover is shaken up with a tedder before noon; at 1 o'clock it is raked into windrows, immediately bunched with the rake, and hauled into the barn. By this method the hay remains warm and free from outside moisture. The hay must be put in before 5 o'clock or the falling dew will deposit sufficient moisture to cause molding in the barn. Handled in this way clover loses none of its leaves; but it is necessary to use extreme care in not having any outside moisture on the hay, or heating in the mow is apt to take place. For this method to be a success excellent haying weather is necessary. It frequently happens that repeated rains make a prime quality of hay out of the question where the hay is to be cured in the field. In extreme cases the silo is to be recommended as a means of making the best utilization of the rain-threatened hay crop.

**Importance of the leaves for hay.**—A considerable percentage of red clover leaves is apt to be lost during the haying process, owing to their tendency to crumble if dried rather than cured. The leaves are much richer in protein than the stems; while they constitute on an average only about 40 per cent of the total weight of the plant, they contain nearly two-thirds of the protein of the whole plant. Owing to improper methods of harvesting and to untimely rains one-half of the leaves may be lost, thus resulting in a marked deterioration in the feeding value of the hay. Table I indicates the results of the analyses of hay from a single plant of red clover cut when one-fourth the blooms turned brown and cured under cover.

TABLE I.—*Results of analyses<sup>1</sup> of the different parts of the red clover plant.*

Constituents.		Heads.	Stems.	Leaves.	Leaf-stalks.
Protein.....	per cent..	18.25	8.06	24.63	11.16
Moisture.....	do	9.99	8.02	8.70	8.88
Ash.....	do	7.20	5.67	8.39	8.02
Ether extract (fat).....	do	2.86	1.25	5.00	2.18
Crude fiber.....	do	10.29	31.94	13.36	13.08
Nitrogen-free extract.....	do	51.41	42.06	39.92	56.68

<sup>1</sup> Analyses made by the Bureau of Chemistry.

**Stacking red clover hay.**—The same general rules used for stacking other hays apply to the stacking of red clover hay; but it must be remembered that red clover sheds water much less readily than the grasses and for this reason greater care is necessary in building and protecting the stack from the action of rain. It is advisable to build some kind of foundation for the stack. This foundation may be composed of poles or rails or other less valuable hay. By care in stacking a comparatively large bulge may be put on the sides of the stack. This reduces the proportion of the hay in the stack bottom and causes the rain to drain off at some distance from the base of the stack. By keeping the middle full and well trampled the hay in settling will settle in such manner as to cause the water to run off rather than into the stack. As red clover absorbs moisture readily that which lies next to the ground is almost sure to be spoiled. If canvas covers are not available for covering hay which must be left outside, it is an excellent plan to top out the stacks with green grass, straw, or millet. After the stacks have settled they should be retopped with more grass or straw, placing an additional layer as far down the sides of the stack as possible. This materially reduces the amount of clover hay exposed to the elements.

When the hay is stacked or stowed away in the barn in a slightly damp condition it is sometimes the practice to mix salt with the same for the double purpose of salting the animals and preventing mold. If the clover must be put up when thought to be a little too green, alternating layers of straw will do much toward absorbing the excess of moisture.

Brown clover hay is made by stacking or mowing away the hay when it has just reached the wilting stage. The air is excluded and it becomes a compact mass. The hay must be free from external moisture if heating is to be avoided. There is therefore some danger of spoiling when this process is attempted by those unfamiliar with the process. This method has a further disadvantage in that the hay is very heavy at the time when it must be handled for stacking.

**Spontaneous combustion of red clover hay.**—When red clover hay is stacked or mowed away with any external moisture on it, such as dew or rain, heating is inevitable until not only the hay itself is damaged, but the heating process may go so far as to cause the entire mass to ignite and burn down the stack or the barn in which the hay has been placed. The absence of air from the mass of heated hay in a barn is often the only thing which prevents it from breaking into a flame, and such instances are made manifest the following winter by the finding of charred masses within the interior of the mow.

### RED CLOVER FOR ENSILAGE.

Red clover may be so readily utilized as pasture or hay that as a rule to ensile it is not advisable; but if inclement weather ensues at the time of cutting for hay it is often advisable to ensile if the facilities are at hand. To make an ideal ensilage the crop should be cut a little earlier than is customary when cutting for hay, but early cutting is usually impracticable if hay is preferred, as the crop will be left uncut several days awaiting favorable haying weather. Although the uncured plants are heavy to handle to ensile them presents the advantage of retaining all their leaves. If sweet silage is desired, it should be dried for an equivalent of three hours of good haying weather before being put into the silo. If a feed cutter is available the clover should be cut before putting it into the silo. The second crop of clover when ensiled is best if mixed with some of the grasses or with Indian corn. The pure red clover silage is apt to be slimy. The more thoroughly it is packed down in the silo when filling the less likely it is to spoil.

### RED CLOVER AS A SOILING CROP.

Where pasturing is impracticable, red clover is often used as a soiling crop—that is, cut and fed green to live stock. Use in this way reduces or eliminates the danger from bloating which attends the use of red clover as pasture. It makes a good early feed, is palatable, and from 6 to 10 tons of green feed per acre is not an unusual yield.

### RED CLOVER AS PASTURE.

Red clover is a most excellent pasture for all stock, especially when they are growing. For pigs it should be supplemented with a small grain ration, as this will induce much more rapid gains. The early growth of red clover is less nutritious pound for pound than when nearing or at the blooming stage, since in the early stages of growth it is high in moisture content, thus requiring the animals to eat relatively larger quantities. Furthermore, close early pasturing is injurious to the stand of clover.

Ordinarily red clover will furnish some pasture during the first fall after spring seeding. It should not be too closely grazed at this time else the succeeding season's hay crop may be decreased. The plants should rather be allowed to go into the winter with some growth upon the crowns in order to prevent their winterkilling and also to enable them to store up material in their roots for an early vigorous growth the following spring.

**Bloating.**—When pasturing cattle or sheep on red clover, care must be taken not to pasture when the animals are very hungry, especially when the red clover is young and succulent or when wet with dew or rain, as bloating may result. Should bloating occur, several remedies are usually at hand which will afford material relief. A large bit, the diameter of a pitchfork handle, may be tied in the mouth; a piece of rubber tubing may be passed through the mouth to the first stomach; or, as a last resort, the animal may be tapped to allow the escape of gas. For this purpose a trocar, such as is used by veterinary surgeons, is best; but in the absence of this, a small-bladed knife may be used to make the incision about 6

inches in front of and slightly below the left hip bone. A straw or quill may be used to permit the escape of gas. Care should be taken not to allow the straw or quill to work down out of sight into the incision.<sup>1</sup>

### RED CLOVER AS A FEED.

All farm animals require protein in some form in order to make their best growth or to produce the best results either in the form of milk and butter, as in the case of dairy stock, or as eggs, in the case of poultry. The ordinary roughage, such as corn stover and ordinary grass hay, is low in the necessary protein. On many farms this protein is supplied by feeding such concentrates as bran, oil meal, or cottonseed meal; but these concentrates are expensive and on most farms should be in large measure replaced by a leguminous forage crop, such as red clover, which can be grown on the place.

Red clover is one of the most highly nutritious forage plants, either in the green state or cured as hay. Tables II and III show the results of experiments to determine the relative values of several different kinds of feed.

TABLE II.—Average composition and digestibility of red clover and other forage plants.

Designation of data.	Fresh clover.	Fresh alfalfa.	Clover hay.	Alfalfa hay.	Timothy hay.	Cowpea hay.
COMPOSITION. <sup>1</sup>						
Number of analyses.....	43	23	38	21	68	8
Constituents:						
Water.....per cent..	70.8	71.8	15.3	8.4	13.2	10.7
Ash.....do.....	2.1	2.7	6.2	7.4	4.4	7.5
Protein.....do.....	4.4	4.8	12.3	14.3	5.9	16.6
Crude fiber.....do.....	8.1	7.4	24.8	25.0	29.0	20.1
Nitrogen-free extract.....do.....	13.5	12.3	38.1	42.7	45.0	42.2
Ether extract (fat).....do.....	1.1	1.0	3.3	2.2	2.5	2.2
DIGESTIBILITY. <sup>2</sup>						
Number of experiments.....	2	2	46	28	26	2
Constituents:						
Protein.....per cent..	67	81	55	73	48	65
Crude fiber.....do.....	53	45	49	43	52	43
Nitrogen-free extract.....do.....	78	76	69	60	63	71
Ether extract (fat).....do.....	65	52	53	54	57	50

<sup>1</sup> In part from Henry's "Feeds and Feeding," Appendix.

<sup>2</sup> Experiments with ruminants.

TABLE III.—Digestible nutrients in and feeding value of red clover and other forage crops.

Kind of forage.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds.			Feeding value per ton.
		Protein.	Carbohydrates.	Ether extract (fat).	
	Pounds.	Pounds.	Pounds.	Pounds.	
Fresh clover.....	29.2	2.9	14.8	0.7	\$5.96
Fresh alfalfa.....	28.2	3.9	12.7	0.5	7.00
Clover hay.....	84.7	6.8	35.8	1.7	14.12
Alfalfa hay.....	91.6	11.0	39.6	1.2	20.16
Timothy hay.....	80.8	2.8	43.4	1.4	9.64
Cowpea hay.....	89.3	10.8	38.6	1.1	19.76
Wheat bran.....	88.1	12.2	39.2	2.7	22.07
Shelled corn.....	89.1	7.9	66.7	4.3	20.16

<sup>1</sup> See "Diseases of Cattle," a special report of the Bureau of Animal Industry.

The last column of Table III shows the actual feeding value of the eight different kinds of feed. These figures are based on the amount of digestible nutrients present in the respective feeds, the following money values per pound being assigned as a basis of calculation: Protein, 6.74 cents; carbohydrates (starches, etc.), 0.64 cents; ether extract (fats), 1.12 cents. These figures are merely relative, as the prices of the food elements vary somewhat in the different sections and from year to year. It will be noted that clover hay is worth nearly one-half more per ton than is a similar grade of timothy hay.

### RED CLOVER IN MIXTURES.

For ordinary farm purposes it is very often advantageous to seed red clover in a mixture with other clovers and tame grasses. The root systems of the different species are not the same, and as a result the soils of both the upper and lower layers are more fully occupied than they would be by a stand of a single crop. In case the stand is to be used for pasture, the mixture will usually insure better succession of good pasturage than would the use of any single crop; that is, by proper selection of the constituents of the mixture it is possible to obtain a pasture which will provide for early as well as late grazing and at the same time give fair returns during the heated months of summer. Probably the most common mixture is red clover and timothy. In the Ohio River section and westward it is customary to seed the timothy with winter wheat and follow this up the next spring with red clover on the new stand of wheat when the ground is honeycombed by frosts. In the spring-wheat section the timothy is seeded with the red clover at the same time the wheat is sown. The timothy is longer lived than the red clover, and as a result the proportion of timothy in the mixture of the hay increases very rapidly after the second season. Ordinary red clover matures about two weeks earlier than the timothy, and for this reason the Mammoth clover, being about two weeks later, is frequently used for seeding in mixtures with the timothy. Other mixtures suitable for hay are red clover combined with orchard grass, tall meadow cat-grass, and a small admixture of alsike clover. In any low places which may exist in the meadow it is advisable to replace the orchard grass with redtop and at least half of the red clover with alsike. At the North Dakota experiment station red clover seeded alone produced an average of 3,265 pounds per acre, whereas a mixture of red clover and timothy averaged 3,356 pounds per acre. Each of these weighings included only the first cutting; if the second cutting had been included the red clover seeded alone would have given a considerably larger total, as timothy produces little second growth. On rough-land pastures red clover may also form a minor constituent of a regular mixture of bluegrass and white clover.

### EFFECT OF RED CLOVER ON THE LAND.

The clovers have been justly ranked as the principal foundation of a permanent system of agriculture in the northern and eastern United States. By the proper utilization of the clover in the rotations it is possible permanently to maintain the supply of nitrogen and humus in the soil. The fertilizing value of red clover is not entirely in

the hay which would be plowed under if the crop were to be used for green manure. Experiments show that 30 to 50 per cent of the fertilizer value of the clover may lie in the roots and stubble which are plowed under, even though the hay crop is removed. In one experiment the Delaware experiment station found that the red clover produced on an acre contained 122 pounds of nitrogen, 68 pounds of potash, and 28 pounds of phosphoric acid. At present prices for fertilizers one ton of clover hay contains nearly \$10 worth of fertilizing elements. It frequently happens that the yields of grain crops are increased as much as 10 bushels to the acre by turning under clover sod, but too much must not be expected of red clover. The only real addition it makes to the land is the humus it supplies, together with the nitrogen it is able to extract from the air. The other fertilizer elements, such as potash and phosphoric acid, must needs be drawn from the soil itself. As soils commencing to give low yields are likely to be low in nitrates, the use of clover will bring largely increased returns for a number of years, until the other fertilizer elements begin to be depleted. Under such conditions the clover acts in one sense as a stimulant to the soil, in that it induces the soil to give up larger quantities of the other fertilizer elements than it would otherwise be called upon to do. Inasmuch as phosphoric acid and potash are not added to the soil by the growth of red clover thereon, it is ultimately necessary to supply these in the form of commercial fertilizers or in the form of barnyard manure, from time to time. By feeding the crops on the farm and returning the manure to the land the fertility of the soil can usually be maintained for many years without the addition of commercial fertilizers.

### RED CLOVER IN ROTATIONS.

One reason for the great popularity of the red clover plant is the ease with which it lends itself to the rotations which have been practiced in the sections to which it is adapted. The fact that it lives but two years necessitates a rather short rotation on the farm, especially when the clover is seeded alone. Meadows and pastures containing clover and grass mixed are usually held three or four years, even though very little clover may remain during the last year or two. The value of the red clover on the farm makes it usually desirable that a considerable area of the farm be at all times seeded to this crop. The possibility of obtaining a grain crop during the season when the red clover is making its early growth, makes the utilization of this legume in maintaining soil fertility a thoroughly practicable one, not calling for an undue amount of special preparation or fertilizers to maintain successful stands upon the ordinary farm. If the land be in a somewhat depleted condition as regards fertility a 3-year rotation with clover is best, although on better soils a 4-year or even a 5-year rotation may be practicable. The Illinois experiment station has shown as a result of a 30-year test that corn on land continuously has produced 25 bushels to the acre; corn alternated with oats, 43 bushels; while corn, oats, and clover in a 3-year rotation gave a yield of 59 bushels for the corn.

**Clover in rotation with corn, oats, and wheat.**—A common rotation in the clover belt is corn followed by oats which in turn are followed

by wheat. The wheat in turn acts as a nurse crop for the clover sown with it. After clover has stood two years the clover sod is plowed down for corn again. There has been for some time a tendency on the part of farmers to discontinue the wheat crop on the farm wherever possible, owing to some uncertainty in the results. When wheat is eliminated from the rotation the clover is seeded at the same time with the oats in the spring. Under certain conditions a second crop of corn may replace the oats in the rotation. The oats may be eliminated without substituting any crop, making the rotation corn, wheat, and clover—a 3-year rotation adapted to soils which are hardly strong enough to stand three crops between the clover crops. The substitution of the second crop of corn for the oats is made if additional corn is required, as for carrying an increased number of hogs.

**Clover in rotations including rye.**—Rye may be substituted for wheat in the rotations already discussed. It has some points of advantage over wheat in that it grows taller and stools less and therefore does not shade the clover so much. The seed is sown in the spring under usual conditions. The harrow may be used on the rye to cover the clover, the same as on wheat, and likewise the disk harrow or drill. One method is to seed the clover on the rye and then to pasture it early with hogs. The trampling of these animals over the field will work much of the seed into the ground and make a stand more certain. A top-dressing of manure or straw or the use of commercial fertilizer can be used in connection with the rye the same as with wheat. The rotations including rye are on much the same general plan as those with wheat.

**Clover in rotations with spring-seeded cereals.**—In sections north of the winter-wheat belt it is usually the practice to seed the clover with spring-sown grain. It is manifestly impossible to rely on frosts to cover the seed, as the ground must be comparatively warm before being worked for the reception of the grain crop. In some cases, as for instance if the soil is so sandy as to call for the seeding of the clover to a depth of 2 inches, the clover seed may be drilled in with the grain at one operation. On heavier soils and where a covering of only an inch is required, the seeding may be made broadcast either before or after the drill, or by a seeding attachment on the drill. The seed should be covered with a harrow following the drill, as it is usually impossible to cover the seed deeply enough if seeded in front of the drill shoes. It is often advisable on light soils to follow the harrow with a roller which firms the ground around the seed, inducing prompt germination. A corrugated rather than a smooth roller is to be preferred. It is necessary to seed the grain crop somewhat lighter than if clover were not seeded with the grain. Barley stools less than either oats or wheat and on this account is more desirable as a nurse crop. Oats are especially bad about stooling broadly and shading out the young clover plants. When the grain crop comes into head close watch must be kept of the moisture condition of the soil, as, if there is any considerable lack of rain, the grain crop should be cut for hay or at least somewhat before it would ordinarily be cut for grain. Unless this is done the young clover plants may be robbed of their much-needed moisture; but sometimes the grain crop may be considered the more important of the two if either has to be sacrificed.

**Rotations containing cowpeas or soy beans preceding wheat and clover.**—In sections where cowpeas and soy beans are successfully produced it is sometimes the practice to introduce one of these coarse legumes immediately preceding the wheat crop. The vines are either cut in time to have the ground ready for fall seeding or the entire pea or bean crop is rolled down and then cross-disked. The accumulation of the cowpea or soy bean stems and leaves on and near the surface serves as a mulch which acts very beneficially on the clover. The practice of turning the entire crop of both pods and vines back to the soil, however, is somewhat wasteful and it is better to pasture the pods off with hogs. This method allows only the vines to go back to the soil, thus giving the same results as regards the crop of clover besides converting a portion of the crop into pork.

**Rotations of corn and clover only.**—This type of rotation is not common, as it requires considerably more labor than other methods already outlined. The rotations usually are two crops of corn followed by a clover crop lasting either one or two years. The clover in such rotations is sown either in the corn at the last cultivation or in the spring in the stubble without a nurse crop. Both of these methods are open to objections on the part of average farmers. Under ordinary conditions the first method, that of seeding in corn at the last cultivation, is uncertain, especially if there are no rains at the time of seeding; but on rich black soils when especial care has been taken to have the land in fine condition it is proving successful. (Fig. 9.) On average soils and with the average tillage which the cornfields receive, it is not to be recommended to the average farmer except in a small way as an experiment. The second method, that of seeding in the spring without a nurse crop, has been found to be a very certain method of getting a good stand of clover. This method gives the clover the entire use of the ground from the start, and unless the ground is infested with weeds the clover makes a very good growth the first season and will give a fair cutting of hay. Clipping in early summer will often overcome the evil effect of weeds. This method, however, is not to be advised on soils badly infested with weeds, as the weeds will usually do more injury to the young clover than the customary nurse crop of grain.

**Clover in rotations on farms not carrying live stock.**—The rotations already discussed are especially adapted to farms carrying sufficient live stock to consume the hay and roughage produced on the farm. Under conditions where such a system of farming is not feasible a modification of the clover rotation is essential. This may be brought about by the use of Mammoth clover in the rotation. Since this produces but one crop it should be a crop of seed. This will bring in favorable seasons a very good cash return from the ground, and the clover straw and chaff may be returned to the land and plowed under. The actual quantity of soil fertility carried away with an ordinary crop of clover seed is comparatively small. After the crop of seed is removed and the straw again scattered over the field the land may be immediately put into some other crop. There will be less clover straw to scatter if the stubble is cut high so as merely to get all the heads. In some sections grain headers are in successful operation where the clover fields are large. (Fig. 12.)

**Rotations including cotton.**—Although cowpeas and soy beans are the customary soil improvers throughout the South, certain conditions exist, especially on the black prairie soils, where red clover may serve as an important crop in alternation with cotton. The clover can be seeded in the cotton just before or after picking time and will make sufficient growth for a crop of hay by the time the cotton is to be reseeded the next spring. The stubble can be worked up in connection with the fitting of the ground for cotton.

### SEED PRODUCTION OF RED CLOVER.

The extensive production of red clover in this country is due to the production of a few acres on a large number of farms rather than to the production of large areas on farms devoted primarily to this crop. For this reason the clover crop is too often an incident and not the main issue on the farm. The various successful experiences of occasional farmers in sections where the average production of red clover



FIG. 12.—Grain header at work in a clover field.

seed is very low indicate that much is to be learned regarding the essentials of the successful production of the crop of red clover seed. Where these essentials are understood, it is usually not hard to provide for them and thus materially increase the seed crop. In practically all of the areas adapted to the production of red clover hay fairly satisfactory crops of seed are also produced. Red clover differs in this respect from alfalfa, which is grown for hay over extended areas where seed production is not practicable.<sup>1</sup>

### HANDLING CLOVER FOR SEED.

In order to produce the best crops of seed the conditions should be such as to retard somewhat the production of the largest vegetative growth, as the conditions which will produce a medium growth

<sup>1</sup> See Farmers' Bulletin 339, entitled "Alfalfa," by J. M. Westgate.

of the plant will usually induce the best set of seed. When the growth of the clover is so rank as to lodge, the heads are apt to be comparatively few and not well filled with seed.

The time of cutting the first crop for hay has a marked effect on the second crop, which is the one usually allowed to stand for seed. As already indicated, the best hay is produced when the crop is cut a little past full bloom; but this may or may not be the best time within a given section to cut the first crop, if due consideration is given to the production of maximum yields of seed where seed is relatively more important than the difference of a few days in the time of cutting the hay crop. For the sake of the succeeding seed crop the first cutting for hay should be made a little before full bloom rather than after the first blossoms have begun to turn brown. As a specific instance it may be cited that mowing was commenced on one side of a 40-acre clover field when the plants were two-thirds in bloom. Several days were required to cut the field and the last of the clover was not cut until the plants were just past full bloom. The effect of this time of cutting on the seed crop was remarkable in that the early cutting induced the second crop to produce seed at the rate of 5 bushels per acre, whereas the cutting a week later resulted in a subsequent seed yield of only 2 bushels. The difference in the value of the preceding hay crop by reason of the early cutting on the one side was probably not more than 20 per cent, whereas its increase of the yield of seed was more than 100 per cent.

A number of conditions may arise which make it inadvisable to attempt to produce a full crop of hay if it is desired to produce a maximum crop of seed.

In the Ohio Valley States the ravages of the various insect enemies may be materially checked by pasturing the clover or even by clipping it considerably earlier than is demanded by the hay crop, as this process tends to destroy insect enemies which would otherwise be developing to work havoc in the succeeding seed crop. In the northern portion of the northern tier of States the short growing season will not usually permit the first crop to reach full bloom and still allow time for the maturing of a seed crop. For this reason it is usually necessary to pasture the crop or cut it earlier than would otherwise be necessary. If a full cutting of the first crop of clover is made for hay and the second left for seed, the seed yield is likely to be disappointing on account of the lack of suitable growing weather for the seed crop. In the latitude of northern Michigan the clover may be pastured until June 18 or 20 in normal seasons and then allowed to produce seed. If stock for pasturing is not available, the clover may be clipped back about the middle of June with equally good results. Even when the land is pastured it is a good practice to run the mower over the field after the stock is removed to clip back any bunches which may be left by the stock. In this way the seed crop will mature much more evenly over the entire field. The reasons for the increase of the seed yield due to clipping or pasturing back are not well understood. It is claimed by some that this brings the setting of the seed at a time when the necessary dry weather is apt to be prevalent. Another reason is the avoiding of injurious insects which would be present if the clover had matured a few weeks later. Another reason is that if pastured or clipped back the plants do not

grow so rank and are less likely to lodge and fall down, thus enabling them to bloom more freely with a consequent larger seed crop. Another advantage is in having much less straw to handle at thrashing time.

### ESTIMATING THE PROBABLE SEED CROP.

Inasmuch as the clover straw is of little value as hay, if the crop is allowed to go to seed a decision must be made when the field is a little past full bloom as to whether the second cutting should be allowed to stand for seed or be used for hay. It is usually possible to estimate with fair accuracy the probable seed production by the time the plants are well out of bloom. If examination of the field shows a uniform stand of a goodly number of heads with an average setting of 25 or 30 seeds to the head, it may be taken as an indication of a sufficiently good crop to pay for the seed, as under normal conditions this indicates a yield of 1 to 2 bushels per acre. If the heads which are turning brown show less than 20 seeds to the head, it will usually be better to cut the crop for hay even though it is a little too late for the best quality of hay.

### HARVESTING THE RED CLOVER SEED CROP.

Under normal conditions the stand of red clover should be cut when the heads have turned dark brown and most of the seeds have reached the dough stage. If left much later than this stage the heads become brittle and break off in the process of harvesting. On the other hand, it is inadvisable to cut the clover when the seeds are in the soft dough stage, expecting them to ripen after cutting, as light, shriveled seed is likely to result. If the clover is a little overripe, the loss of heads may be materially reduced by cutting early in the morning or in the evening, when the straw is less brittle by reason of the dew. The red clover should be cut as high as possible, as this will enable thrashing to be done with less trouble from the straw. Headers similar to or identical with the grain headers are sometimes used. (Fig. 12.) Many farmers use a mower with a fingerlike attachment behind the cutter bar for bunching the clover behind the wheels, so as to be out of the way of the trampling of the horses on the next round. Another buncher is tripped by the foot, the guide rods pushing the hay partly to one side before the buncher is tripped. In the absence of such an arrangement, the ordinary mower may be followed by men who remove with barley forks the clover from the path of the mower and horses. An old-fashioned self-rake reaper is probably as satisfactory an implement as can be used. In many cases, however, no special devices are used to prevent injury by the mowing-machine wheels and the trampling of the horses.

The bunches left behind the mower may be allowed to remain as they are or may be piled two or three together. The cocks must be watched in rainy weather. If they become moist, the seed is apt to sprout. It must be remembered that the less handling the clover is given the less will be the loss of seed from shattering. Danger of the seed sprouting is incurred if the clover continues damp, but hulling is greatly facilitated if the clover is alternately somewhat wet and

dry. It usually requires at least four days to properly cure for hulling, although two weeks or more may intervene between cutting and hulling. It is the common practice to hull directly from the field, as hulling from a stack or barn calls for extra handling with attendant loss of seed. On the other hand, a heavy seed crop may often be put under cover to advantage, especially if the season be rainy. It is the usual custom to hull the seed with a special red clover huller. In principle this machine acts as an ordinary grain thrashing machine in removing and breaking up the heads, which are then passed underneath the cylinder where the individual clover seed pods with the inclosed seeds are rubbed out by rasps or other special devices. (Fig. 13.) The huller will not do good work when the clover is at all damp even from dew; hence six hours is usually found to be a good day's run when hulling from the field. A grain thrasher with a clover attachment is sometimes used, but this is less satisfactory because it

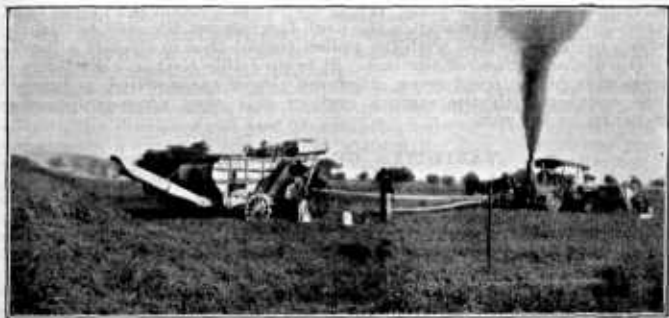


FIG. 13.—Clover huller at work.

is often necessary to run the material through twice. A further disadvantage is that the thrashing machine is likely to be required for grain thrashing at the time the red clover should be hulled.

#### UTILIZATION OF CLOVER STRAW.

The clover straw after the seed has been removed from it is too coarse and unpalatable to be of much value as feed, though sheep and cattle will pick it over during the winter. It may be scattered back on the field with good effect on the land. The chaff may also be used as an absorbent of liquid in stables. It is an excellent plan to apply the clover straw and chaff to thin spots in the fields which are to be in clover the succeeding year. This method materially improves the inoculation and tends to increase the productivity of the clover and other crops.

If the clover is cut for seed and cured without having been rained upon, the straw has some feeding value, but such instances are unusual.

## RELATION OF POLLINIZING INSECTS TO THE PRODUCTION OF RED CLOVER SEED.

Numerous experiments have shown that if the heads of red clover are bagged to exclude insects little or no seed is produced, indicating that without external assistance of some kind the red clover plant is unable to set seed. It is not necessarily sterile to its own pollen, as experiments have shown that if the flower's own pollen be rubbed into the stigma, imitating the action of a bumblebee in visiting the plant, seed will be produced. Under field conditions, however, it is necessary to rely upon the visits of insects for the successful setting of the seed crop. Machines are being experimented with which imitate the action of the bumblebee and which may eventually place the seed crop upon a more certain basis, as at present the absence of suitable pollinizing insects usually reduces the crop of clover seed. Bumblebees are commonly supposed to be the most efficient agencies in the pollinization of red clover. When the bee alights on the clover head, its weight presses down upon the keel, forcing out the stigma (female) which becomes dusted with the pollen (male) that is already adhering to the under surface of the bee. It is probable that in a majority of cases it is pollen from some other red clover plant which is brought into contact with the stigma and in this way cross-pollinization seems to be the rule.

## VARIETIES OF RED CLOVER.

There are a number of varieties of red clover, each more or less adapted to some special purpose or to certain sections.

**Ordinary red clover.**—Red clover (*Trifolium pratense*) is the most important member of the group of true clovers, although there are other important varieties and species. Under conditions where red clover succeeds it is the best general-purpose clover. It will usually produce both a crop of hay and a succeeding crop of seed in the same season. It has the further advantage of succeeding under ordinary conditions when seeded in connection with a grain crop, thus calling for very little extra labor when it is desired to establish a stand on the farm.

**Mammoth clover.**—Mammoth clover, also known as Sapling clover, Pea Vine clover, Bull clover, and Perennial clover, is only a form of the ordinary red clover and is not sufficiently distinct botanically from *Trifolium pratense*, the ordinary red clover, to receive a botanical varietal name. It is not the "zigzag clover" of northern Europe, known as *Trifolium medium*, which latter name has often been misapplied to Mammoth clover. Mammoth clover is about two weeks later in maturing than the ordinary red, and it is partly owing to this fact that it is impracticable to harvest both a hay crop and a seed crop the same season. Mammoth clover is useful in seeding with timothy for hay, because it and the timothy bloom at the same time, whereas ordinary red clover blooms too early for the best results in cutting the timothy. The large size of Mammoth clover plants makes them of slightly greater value as a soil improver, and in addition the seed yield is usually larger. The one crop of Mammoth clover is somewhat less than the two crops of ordinary red clover, but may be

more economical owing to the greater cost of harvesting two crops of the ordinary clover. On low ground the stems of Mammoth clover are apt to become somewhat woody. It grows less rank on poor soils, where it is ordinarily grown, rather than on the heavier soils. Furthermore, on the poorer soils it is excellent as a seed-producing crop, being used in a rotation of corn, grain, and clover, each one year; the Mammoth clover is allowed to stand for seed and no attempt is made to utilize the hay other than for returning fertility to the land. The variation in the time of maturity of this clover enables it to avoid many of the insect pests which greatly injure the fields of ordinary clover. This item is important in reducing the injury from many of the insects which play havoc with the successful production of seed of the ordinary red clover. The seed of the Mammoth clover is slightly larger than and is recommended above either the ordinary or alsike on poor sandy lands in the North. If grown for hay it should be cut when in early bloom, rather than when past bloom, on account of the tendency of the stems to become woody. In the northern part of the tier of Northern States where only one crop of ordinary clover is possible Mammoth clover is usually preferred on account of its higher yield.

**Russian red clovers.**—Most of the red clover grown in Russia is without the hairs which are usually present on the stems and leaves of both the ordinary red and Mammoth clovers. This smoothness is apparently a distinct advantage because the hay is rendered much less dusty. These clovers do not appear to be so well adapted to growth farther south and they are quite as late in maturing as the Mammoth clover. The first cutting in the Northern States will usually exceed the ordinary variety, but like the Mammoth clover it produces little or no second crop. Seed of these Russian clovers is not usually available on the market.

**Special forms of red clover.**—In addition to the three varieties of red clover already mentioned certain disease-resistant strains are being developed which may prove of material value in overcoming some of the handicaps under which red clover labors where diseases are present which hinder its growth; but these strains are produced to such a limited extent that the seed is not yet on the market in commercial quantities. Preliminary results with these strains suggest the possibility of developing certain forms of red clover adapted to the peculiar conditions which are present in many sections of the country.

## OTHER SPECIES OF CLOVER COMPARED WITH RED CLOVER.

### TRUE CLOVERS.

**White clover.**—The low-growing, shallow-rooted white clover (*Trifolium repens*) is adapted only for pasturage, as it does not attain sufficient height to be mown for hay. The seed crop matures in July and August in the Northern States. Yields of seed vary from 2 to 6 bushels per acre, and the price is about the same per bushel as that of red clover. A 2-year rotation of barley one year followed by white clover for seed the second is common in central-eastern Wisconsin. Elsewhere it is usually seeded in a mixture with bluegrass and rarely if ever causes bloat as red clover is apt to do.

**Giant White or Ladino clover.**—A tall-growing variety of white clover (*Trifolium repens* var. *lata*), first experimented with in this country by the North Carolina experiment station, was procured in Italy and may be imported thence in limited quantities. It grows several times taller than the ordinary white clover but not so tall as either the alsike or the ordinary red clover. It furnishes an excellent yield of good pasturage and makes sufficient growth to be cut for hay. The stems grow prostrate and only the elongated leafstalks and leaves are used for hay, which is a very nutritious feed but is somewhat hard to cure.

**Alsike clover.**—Intermediate in general appearance between the white and red clovers, and erroneously supposed to be a hybrid between the two, is alsike clover (*Trifolium hybridum*), also called Swedish clover. Alsike is especially adapted to wet soils and also to soils which are too low in humus to grow red clover to advantage. Seed may be taken from the first crop, although an early clipping (especially if the spring is unusually wet) will usually result in a better crop of seed. The blooms are excellent as honey producers. In comparison with red clover, which lasts only two years, the alsike lasts for three to five years or even longer. The seed is much smaller and 4 to 8 pounds per acre is an ample seeding. The hay is somewhat richer pound for pound than the ordinary red clover, but only one crop is procurable and this is not generally as heavy as even the first crop usually produced by the ordinary red clover. It is hardier than either the Mammoth or ordinary clover, but lodges worse than either. For this reason it is usually best to seed it in mixture either with ordinary red clover or with orchard grass to prevent its lodging. In some sections where red clover is no longer grown successfully the farmers have been forced to adopt the alsike. The continuous use of pure alsike clover either as pasture or as hay has a tendency to produce sores on both horses and mules.

**Crimson clover.**—Crimson clover (*Trifolium incarnatum*) is especially adapted as a cover crop and for green manure in the Atlantic States. It is easily recognized by its scarlet blooms. It is seeded in August either alone or in corn. Its special advantage lies in that its autumn, winter, and early-spring growth is sufficient so that it may be turned under in the spring following the seeding in time for another crop, such as corn or even cotton, in the South Atlantic States. It is also valuable for pasturing, soiling, or for ensilage, coming at a time when other green feed is scarce. One disadvantage in feeding the hay if cut when overripe is the tendency of the hairs, which are numerous on parts of the plant, to form hair balls in the alimentary tract of horses.

**Shaftal clover.**—Shaftal clover (*Trifolium suaveolens*) has recently been obtained from Persia and is not yet on the market in commercial quantities. It is usually seeded in the fall and is somewhat similar to crimson clover in its requirements and growth. The seed is as yet very expensive. Moreover it lodges badly and is difficult to cure. These disadvantages handicap its more extensive production. Ordinarily this clover is a winter annual, maturing seed and dying the first summer after seeding; but a perennial strain is reported as growing in northern India.

## SO-CALLED CLOVERS.

**Sweet clover.**—Sweet clover (*Melilotus alba*) is often regarded as of little or no value as a forage crop on account of its bitter taste; but stock may acquire a taste for it, and then it proves a very satisfactory feed. It will grow on clay hills, on sandy stretches in the clover section, and also makes a satisfactory growth in sections where it is too dry to grow red clover. It is a biennial, living only two years, being similar in this respect to red clover. A permanent stand may be maintained by dividing the pasture and alternately grazing and mowing the two halves.

**Lespedeza, or Japan clover.**—Lespedeza (*Lespedeza striata*) is distinctly a southern plant and makes very small growth north of the latitude of Virginia. In the extreme Southern States it makes a growth comparable with the true clovers and is a useful plant to supplement the winter-growing clovers which do not thrive in the hot summer months as does lespedeza.<sup>1</sup>

**Mexican clover.**—Mexican clover (*Richardsonia scabra*) is not a true clover nor even a legume. It occurs principally along the Gulf coast in the Southern States. It grows spontaneously after cultivated crops are removed, being usually associated with crab-grass. The seed is not usually on the market.

## ENEMIES OF RED CLOVER.

The principal enemies of red clover are insects, fungous diseases, and weeds. Occasionally burrowing rodents, such as mice and gophers, do some damage, usually not at all serious. Of the enemies just mentioned the insect pests are usually more troublesome than either the fungous diseases or weeds.

## INSECT ENEMIES.

Red clover is affected by a number of insects which at one time or another during its existence tend to destroy the life of the plant. Many insects feed to a greater or less extent on the red clover plant, but comparatively few of them do enough material harm to affect seriously the production of clover over extended areas. For a full discussion of the enemies of red clover the reader is referred to the publications of the Bureau of Entomology of the United States Department of Agriculture,<sup>2</sup> and also to the bulletins on this topic issued by most of the experiment stations in the clover-growing States.

**The clover root-borer.**—For over 30 years the clover root-borer (*Hylastinus obscurus* Marsh) has done an immense amount of damage in the clover-producing States east of the Mississippi River. This insect is especially destructive in Ohio, Indiana, and southern Michigan. At one time this pest threatened the entire clover-growing industry of Michigan. The beetle has a hard body about one-sixth of an inch in length (fig. 14), and its color is dark brown. It is perhaps best recognized by the effect of the larva (fig. 15) on the

<sup>1</sup> See Farmers' Bulletin 441, entitled "Lespedeza, or Japan Clover," by A. D. McNair and W. B. Mercer.

<sup>2</sup> Circular 69, Some Insects Affecting the Production of Red Clover Seed; Circular 110, The Clover Root-borer; Bulletin 85, pt. 1, The Lesser Clover-leaf Weevil; Bulletin 85, pt. 3, The Clover-root Curculio.

root of the plant, which is shown in the accompanying illustration (fig. 16). These insects do not materially damage the stand of clover until the summer of the second year, because the roots must reach a considerable size before they are capable of harboring the beetles. It is the larvæ rather than the adult insects which work the actual destruction of the roots of the red clover. The only preventive measure yet tried is to turn down the clover stubble as soon as the hay crop is removed. At this time the root-borers are in an immature



FIG. 14.—The adult insect of the clover root-borer (*Hylastinus obacurus*). A natural-size representation is shown at the right.



FIG. 15.—The larva (grub or maggot) of the clover root-borer. It is in this stage that the insect does most damage to the clover roots. Much enlarged.



FIG. 16.—Clover root, showing the work of the clover root-borer. (Slightly enlarged.)

stage and deprived of their food must perish as they can not migrate. If this plowing is delayed until later in the fall the larvæ will have developed to the pupæ and adults and the plowing will have little if any effect upon them.

**The clover-seed chalcis fly.**—A little black wasplike insect (fig. 17) about the size of the red clover seed, known as the clover-seed chalcis fly (*Bruchophagus fovealis* How.), may frequently be seen emerging from a recently thrashed crop of this seed. At present this insect is one of the worst clover pests in the United States, being largely responsible for many of the low yields of clover seed. The eggs are laid in the newly developed seed before it is entirely hardened; the larva then develops within the seed which it eats entirely away before emerging as the adult (fig. 18). It is probable that light

early pasturing or clipping of the first growth in the spring will materially reduce the danger from this pest; by bringing on the seed crop later than usual the destructive work of the insects may be largely prevented.

**The clover-flower midge.**—Damage to the clover plant by the clover-flower midge (*Dasyneura leguminicola* Lintn.) is occasioned by the maggots (fig. 19), which develop in the florets and prevent them from setting seed. Even the flower is injured (fig. 20) in its development so that the entire field may take on a different aspect when suffering from the serious ravages of this pest. (Fig. 21.) This small insect

is a near relative of the wheat midge. It may be controlled by cutting the hay quite early, as this will destroy the larvæ of the midge before they have had time to develop into the other stages. By the time the second or fall brood of the midges appears the blooms of the second crop have become too far advanced for the midges to work in them. A second method may be applied where timothy and clover are grown together. The meadows may be pastured lightly or they may be clipped back with a mower set high. This brings the blooming of the subsequent crop of clover too late for the destructive work of the midge.

#### The clover-hay worm.—

The larva of the clover-hay worm (*Hypsopygia costalis* Fab.) works in stacked or stored clover hay. It damages the hay quite as much by the silver web and particles of excrement it leaves behind as in actually eating the hay. It usually attacks the bottom of the clover stack or

mew and such hay is usually refused by horses or cattle. This larva develops into a small brown moth. This insect is best controlled by burning any clover hay which is affected with it and by carefully cleaning out the old clover hay before the new crop is stored. If the hay is stacked outside and the stacks are raised above the ground, as on a foundation of logs, the injury by this insect may be materially reduced. The salting of the hay, especially at the bottom of the stack, or mow, acts as a deterrent to these worms.



FIG. 18.—Sketch showing the effect of the clover-seed chalcis fly; calyx (a), seed capsule (b), and seeds (c and d). At the bottom the mature insect is shown in the act of emerging.

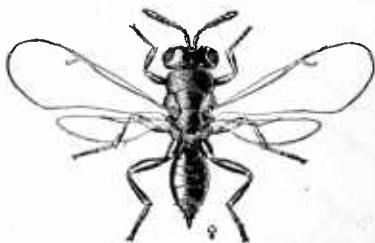


FIG. 17.—Adult insect of the clover-seed chalcis fly (*Bruchophagus fuscicornis*). The wings are ordinarily closely folded along the back.

**The clover-leaf weevil.**—Among the enemies of red clover is the clover-leaf weevil (*Phytanomus punctatus* Fab.). (Fig. 22.) The larvæ hatch in late fall and become full grown in May and the adults appear in July and August. This insect was formerly especially troublesome in Michigan until a fungous enemy of the larvæ developed to a sufficient extent to hold it in check.

One important effect of the clover-leaf weevil is that it may destroy the early foliage. A little later the clover will renew its growth without being permanently affected on account of there being no injury to the roots. This delays the flowering period until after the flower midge has laid its eggs and disappeared. In this respect it is beneficial. The temporary destruction of the early foliage will sometimes lead the farmer to think his clover field has been killed and he will plow up the stand, when really the injury is slight if the field is left alone.

## FUNGUS DISEASES OF RED CLOVER.

All the clovers are comparatively free from the plant diseases which so frequently prove disastrous to other crops; but in certain sections some of these diseases have proved serious, even to the practical elimination of successful stands.

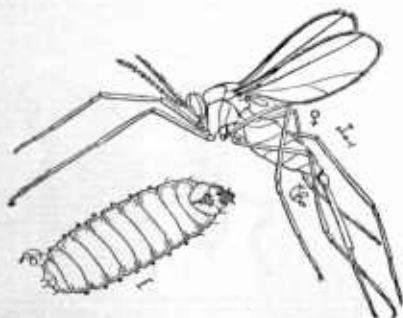


FIG. 19.—Maggot and adult stages of the clover flower midge (*Dasynura leguminicola*). In the clover head the maggot appears as a small red object about one-twelfth of an inch in length.

within the meshes. None of these leaf diseases is usually very serious and when the plants are growing vigorously they are usually able to thrive in spite of the presence of the fungous diseases.

Root-rot (*Rhizoctonia violacea*) occasionally proves destructive to the roots of the clover plant. Stem-rot (*Sclerotinia trifoliorum*) attacks the stems and is characterized by the presence of hard, dark masses of fungous tissue.

The disease known as clover anthracnose (*Colletotrichum trifolii*) has been observed in a number of States, but its ravages have been observed to be especially disastrous only in Tennessee, where, owing to its prevalence, the seedling of red clover is said to have been practically given up. The disease is first manifested by a series of small purple patches which spread on the stem, until if at all badly affected, it is completely encircled, causing the death of the plant.

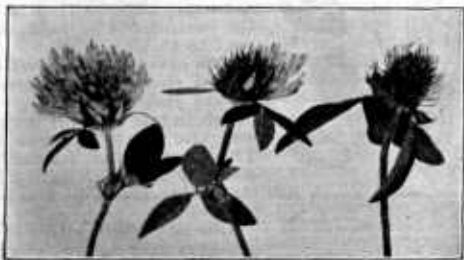


FIG. 20.—Clover heads, showing the effects of the clover-flower midge. The flower head shown at the left is unaffected, the middle head is partly affected, and the head at the right shows all the flowers destroyed by this insect.

The only known direct remedy is in the development of strains resistant to the disease. Considerable progress has been made along this line by the Tennessee experiment station.

### WEEDS.

The seeds of the weeds which are commonly found in red clover are shown in figure 5 (p. 10). From the standpoint of the clover plant itself buckhorn, foxtail, and crab-grass probably form the worst weeds with which the clover plant must contend. Preventive measures alone are ordinarily practicable, as eradication is too expensive except in the case of especially dangerous weeds or weeds large enough to be readily removed just before they mature their seed crop. Thistles and wild carrot plants should be thus removed.

Dodder is one of the worst weeds so far as red clover is concerned. The accompanying illustration (fig. 23) indicates the general appearance of the yellow threadlike vines which attach themselves to the clover plant. The dodder seeds germinate in the ground shortly after the clover seeds sprout. The yellow, threadlike stem of the dodder soon firmly attaches itself to the young clover plant, after which the stem connecting it with the ground withers away. The dodder lives thereafter entirely on the clover plant. Dodder is very difficult to eradicate when once established, and for this reason great care should be taken to avoid introducing it with the red clover at seeding time.<sup>1</sup> Close grazing has been recommended as being effective in holding dodder in check. If it appears in isolated spots through the field, it is advisable to cut the affected areas as low as possible and remove all cut material from the field. Destroying the dodder by burning with different inflammable materials has occasionally proved successful, but it is apt to be more expensive than the close cutting and removal of the affected plants.

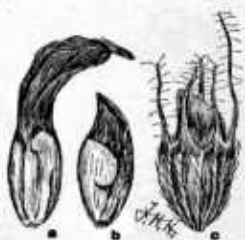


FIG. 21.—Sketch showing the effect of the clover-flower mildew on the individual clover flowers; Clover corolla (a and b). The usual appearance of the shortened corolla with respect to the calyx lobes is shown at c.

### CLOVER-SICKNESS.

Some confusion exists regarding the nature of clover-sickness, a term which appears to have been applied to a great many different causes of clover failure. In Europe this term is used to designate the condition of the land when it fails to grow continuous crops of clover but which will again grow successful crops after an interval of five to eight years. Such a condition would appear to be due either to the exhaustion of some particular element of fertility required by the clover, which would again become gradually stored up in the soil during the years when no clover was grown, or to the presence of some deleterious substance left in the soil by the clover plants, which is gradually eliminated from the surface layers of the soil.

<sup>1</sup> See Farmers' Bulletin 306, entitled "Dodder in Relation to Farm Seeds."

Many sections in this country no longer grow clover as easily as it was formerly grown. Observations indicate that this failure to produce successful stands of clover is not due to any one particular cause but rather to a number of different causes, any one or any combination of which may react very unfavorably on the stand of clover. In some sections the cause of the frequently noted failures with clover has been specifically determined. In Tennessee the presence of the clover anthracnose disease appears to be the principal feature in working against the production of this crop. In Illinois the lack of phosphorus and lime in the soil (often in connection with lack of proper drainage) has been pointed out as a predisposing cause of failure to get stands of red clover. In West Virginia the presence of nematodes on the roots has been observed to react unfavorably on

the stands. In other sections failures have been shown to be due to lack of sufficient quantities of lime in the soil. A primary cause of clover failure which is coming more and more to be recognized lies in the depletion of the original humus supply in the soil by repeated croppings and insufficient return to the soil by means of manure and other vegetative matter. This depletion of the humus makes the soil nonretentive of moisture in time of drought, reducing the growth

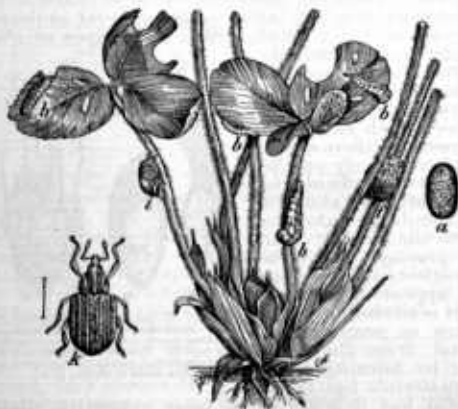


FIG. 22.—The clover-leaf weevil: *a*, Egg; *b, b, b*, larvæ feeding; *f*, cocoon; *i*, beetle, side view; *k*, same, back view; (*b, f, i*, natural size; others more or less enlarged). (Adapted from Riley.)

of the clover plants and rendering them more liable to the attacks of any diseases to which they may happen to be subject. In severe drought or unfavorable winter weather this is apt to prove more disastrous to the stand than if the plants were in the vigorous conditions rendered possible by a soil well filled with humus. It is for this reason that seeding in the spring with a nurse crop has so often failed within recent years. The lack of humus in the ground not only prevents the clover plants from making their best growth but also renders the ground hard and unretentive of moisture, especially when the grain crop is removed. The weakened clover plants are in no condition to withstand the sudden removal of the nurse crop and frequently succumb.

The methods outlined under "Need of experiments with red clover" (p. 20) will indicate whether or not it is possible to overcome the

apparent inability of the soil longer to produce paying stands of red clover. It is probable that there are very few so-called clover-sick sections where clover will not succeed if the ground is well supplied

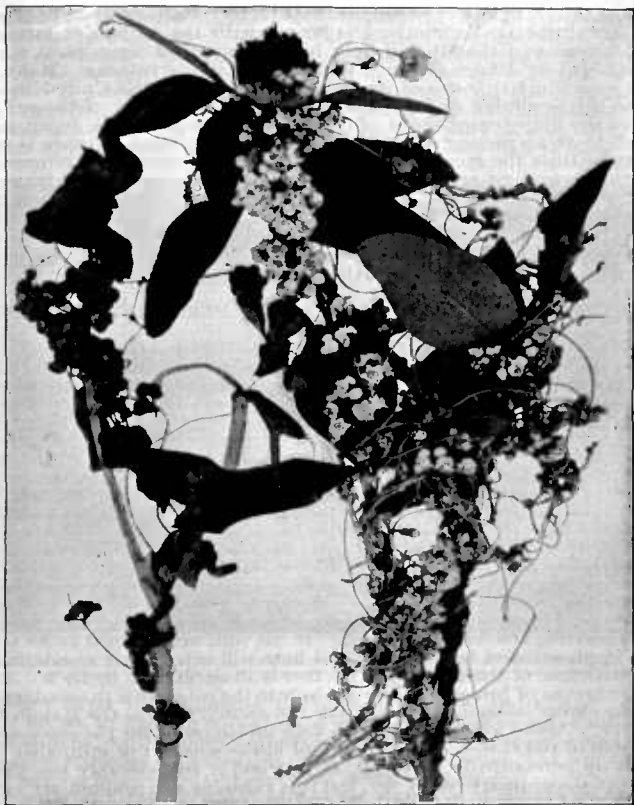


FIG. 23.—Field dodder on stems of red clover. At the right the dodder is shown in flower; at the left, in the mature or seed-producing stage.

with lime and enriched with suitable manure or humus in some form. This is especially true if the clover is seeded alone, thus avoiding the injurious effect of the nurse crop, especially in regard to shading and

the drying out of the soil. It will thus be seen that at least most of the so-called clover-sick lands really only lack one or more of the essential soil constituents to bring them into the proper condition for producing successful stands of clover and other crops.

The failure of clover to produce satisfactory stands should be taken as a warning that something is wrong with the system of farming operations and that it will only be a question of time when other crops will no longer continue to give satisfactory returns. Many of the unproductive farms of the northeastern part of the United States date the beginning of their downfall from the inability of the soil to raise the accustomed crops of clover. This condition is being met with to an increasing extent farther west, and its importance is one that justifies the most serious attention on the part of all interested in the permanent agricultural prosperity of the country. It is probable that with the maintaining of better soil conditions as regards fertilizers—especially humus, phosphoric acid, and lime—in practically all sections the growth of clover will be vigorous enough to withstand the other enemies which have been cited as producing a disastrous effect upon the stands of clover.

## RESTORING CLOVER TO ITS PROPER PLACE IN ROTATIONS.

**Ultimate failure of the usual method.**—Under natural conditions the growing vegetation remaining in place and rotting gradually fills up the soil rather than depletes it, but if crop after crop is removed from the ground much of the valuable plant food is taken away. The loss of humus, among other things, leaves the ground hard and packed. Soils thus depleted do not absorb rains readily and droughts have much greater effect upon them than upon soils under natural conditions. Clover seed sown with the grain crop as in the early days on the surface of the soils thus impoverished usually fails to make satisfactory growth. It is then that special expedients must be adopted in order to retain clover in the farm rotation.

Among the expedients which may be adopted is the increasing of the fertility and humus content of the soil (1) by the application of barnyard manure, (2) by the plowing under of any green-manure crop that will produce sufficiently large growth, or (3) by such extreme measures as the spreading of straw on the land as a means of increasing the humus content. If the soils are inclined to be acid the application of land plaster and lime will often react wonderfully on the vigor of the clover.<sup>1</sup> This fact is illustrated in figure 9. Another means of bringing clover again into the rotation is the seeding of alsike clover instead of using either the ordinary red or the Mammoth clover. Alsike will often grow on soils no longer fit for the successful growth of red clover. The growth of alsike should not ordinarily be kept up permanently, however, as its yield is considerably less than that of the ordinary red clover, but it is valuable as a preliminary crop to be used in connection with the other means of restoring the nitrogen and humus content of the soil and bringing it back to the proper condition for the growth of more valuable strains of clover. Seeding the clover without a nurse crop, thus giving it entire possession of the

<sup>1</sup> See Circular 22, Bureau of Plant Industry, entitled "Farm Methods of Applying Land Plaster," etc., p. 3.

land, will usually be attended with much better results than where the clover is forced to share the land with a nurse crop.

**Top-dressing wheat with manure for clover.**—Under normal conditions where an abundance of manure is properly applied successful catches of clover are obtained with very little difficulty. Fertilizer experiments with red clover have shown the excellent effect which even an ordinary top-dressing of manure will produce. When the soil is badly run down, manure will probably do the most good applied as a top-dressing on the wheat in which the clover is sown. The experience of farmers who have rather heavily top-dressed the poorer spots on the fields to have them produce the best crop of clover under apparently such unfavorable conditions only goes to show the



Fig. 24.—View of a wheat field on which straw has been scattered in preparation for clover seeding. The straw is put on soon after the wheat is sown and the clover is seeded the next spring.

marked effect of manure in producing a crop of red clover. The field shown in figure 8 indicates the effect of a top-dressing of manure as compared with no application of manure. The introduction of the manure spreader in many sections has solved what was becoming the serious problem of the so-called clover-sick lands.

**Scattering straw on wheat ground for clover.**<sup>1</sup>—Along the southern border of the corn-belt States (Illinois, Indiana, and Ohio, especially), on the wheat lands in the hill sections where the ground is becoming deficient in humus and clover seedings very frequently fail, the practice of scattering straw on the wheat in winter and early spring before the seeding of clover germinates is proving to be an important factor in obtaining a successful stand of clover. By this method a catch

<sup>1</sup> For an extended discussion of this method, see Circular III, Ohio Agricultural Experiment Station, entitled "The Management of Clover in Corn-Belt Rotations," by J. A. Drake.

of clover is practically certain where under ordinary conditions it is usually a failure. In some sections even cornstalks are used in this manner as a mulch. This is an expensive undertaking and is attempted only as a last resort, but it indicates the need of the soil for humus and suggests the need of adding humus by less expensive means. Instances in these same sections have also been observed where red clover is successful only when seeded on ground that has previously been in mulched potatoes, the other fields of the farm being too poor in humus. The apparent effect of the wheat straw is to supply an abundant amount of humus, to conserve the moisture, and to prevent surface packing. (See figs. 24 and 25.)

The tendency has been in the past to assign too little importance to the production of humus in the soil, and it is probable that the

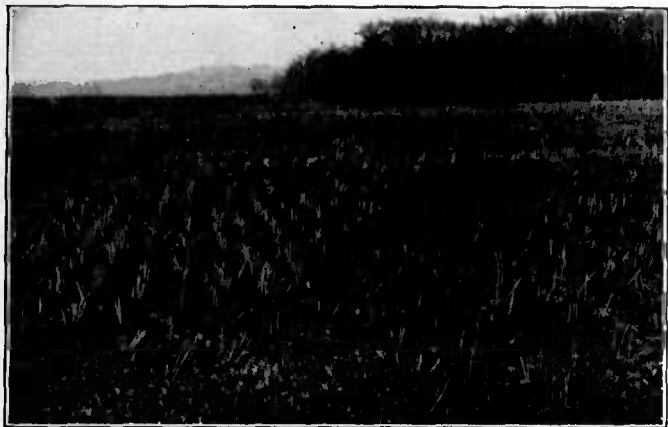


FIG. 25.—View of the field illustrated in figure 24, showing the excellent stand of clover obtained by applying a top-dressing of straw. On some soils clover is likely to prove a failure without this or similar treatment.

difficulty with clover experienced by the farmer in the corn-belt sections is due to the gradual but certain exhaustion of humus.

#### RED CLOVER PRODUCTION IN DIFFERENT SECTIONS OF THE UNITED STATES.

The foregoing general consideration of red clover production has dealt mainly with its growth in the clover-belt States. (Fig. 1.) In this region the clover is seeded with spring grain in the northern sections where winter wheat is not grown. It is also often seeded with spring-sown grain in the Ohio Valley States and immediately westward, although it is a common practice to seed in the spring on the wheat fields which were seeded to wheat the autumn preceding.

In the mountain valleys of the Rocky Mountain States spring seeding with spring-seeded grain is the common practice, while in the Columbian basin (eastern Oregon, eastern Washington, and northern Idaho) in sections where the annual rainfall is at least 20 inches clover may be seeded in the spring, but without a nurse crop, as the summers are very dry.

In western Oregon and western Washington red clover is more generally grown than alfalfa. The clover is seeded either in the spring or fall with the grain, except that when the grain is seeded very late in the fall the clover is not seeded until the following spring. Annual applications of about a hundred pounds of land plaster to the acre are usually necessary.

Red clover grows well in the Southern States on rich limestone soils which are in good condition, but needs to be managed somewhat differently from the methods followed in the Northern States. It should be sown in the fall, as soon as possible after the first of September. When sown at that time on well-prepared and finely pulverized soil, the land being rolled to compact the surface soil and prevent it from drying too quickly, the seed seldom fails to germinate and to make sufficient growth to become well established before cold weather. The crab-grass and weeds which come up with it are killed by the first heavy frost, and when the warm days of spring come the clover grows so rapidly that the weeds are kept down. On good soil it will make from 2 to 2½ tons of hay in May with a lighter crop of hay or a good crop of seed in July. In favorable seasons it will make a third cutting, after which it usually begins to fail; the ground may then be plowed for winter oats. If not plowed under the clover will often make a cutting the following May nearly equal to the first cutting of the preceding season. After this most of the plants die and the ground should be plowed for corn or some other late-planted crop. Red clover is undoubtedly one of the best of the clovers for rich soils which are in a good condition, but it is useless to sow it on barren fields or on rough and poorly prepared lands of any kind. It may be expected to grow on any soil which will grow alfalfa successfully. It has not proved satisfactory on either sandy or "white lime" lands.

### SUMMARY AND CONCLUSIONS.

The production of clover is the foundation of agriculture in the Eastern and North Central States, as upon its successful growth depends to a large extent the maintenance of the nitrogen content of the soils in the principal crop-producing sections. Clover must not be looked upon as a cure-all for farm troubles. Its roots do add large quantities of the very valuable nitrogen and humus to the soil, but aside from bringing up a limited supply of phosphoric acid and potash from the lower layers of the soil it does not add the other important fertilizer elements to the soil upon which it grows; upon many soils these elements (particularly phosphoric acid) must be added the same as though no clover was being grown upon them. So long as the soil is fairly well supplied with humus and is not too greatly depleted of the ordinary fertilizer elements there is usually no difficulty in obtaining successful stands of clover by the ordinary methods of seeding; but when continued cropping

reduces the humus content of the soil to a point below that required for successful clover production it becomes necessary to adopt radical means to restore the ground to its proper condition. It has been repeatedly shown that the failure of the clover in a section is but a prophecy of the early failure of other leading crops in that particular section. The substitution of alsike for ordinary red clover will enable clover to be continued in the rotation on some soils which no longer grow the ordinary red clover. The lack of humus in the soil is the most potent factor in the failure of red clover in these sections, but other factors such as too acid a soil and the presence of fungous diseases or insect enemies, must also be overcome. Liming and proper drainage will overcome the soil acidity. The insects and fungous diseases may be held in check by clipping or cutting at the proper time and by furnishing the proper soil conditions to produce a crop so vigorous that it will succeed in spite of the enemies which prove troublesome to less vigorous stands.

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